

Title: Robert Spekkens and Elie Wolfe, Perimeter Institute

Speakers: Robert Spekkens, Elie Wolfe

Collection: Perimeter Public Lectures

Date: October 07, 2020 - 7:00 PM

URL: <http://pirsa.org/20100024>

Abstract: What do data science and the foundations of quantum theory have to do with one another?

A great deal, it turns out. The particular branch of data science known as causal inference focuses on a problem which is central to disciplines ranging from epidemiology to economics: that of disentangling correlation and causation in statistical data.


Meanwhile, in a slightly different guise, this same problem has been pondered by quantum physicists as part of a continuing effort to make sense of various puzzling quantum phenomena. On top of that, the most celebrated result concerning quantum theory's meaning for the nature of reality — Bell's theorem — can be seen in retrospect to be built on the solution to a particularly challenging problem in causal inference.

Recent efforts to elaborate upon these connections have led to an exciting flow of techniques and insights across the disciplinary divide.

Perimeter researchers Robert Spekkens and Elie Wolfe have done pioneering work studying relations of cause and effect through a quantum foundational lens, and can be counted among a small number of physicists worldwide with expertise in this field.

In their joint webcast from Perimeter on October 7, Spekkens and Wolfe will explore what is happening at the intersection of these two fields and how thinking like a quantum physicist leads to new ways of sussing out cause and effect from correlation patterns in statistical data.

Watch live online at insidetheperimeter.ca.



THE QUANTUM PHYSICIST

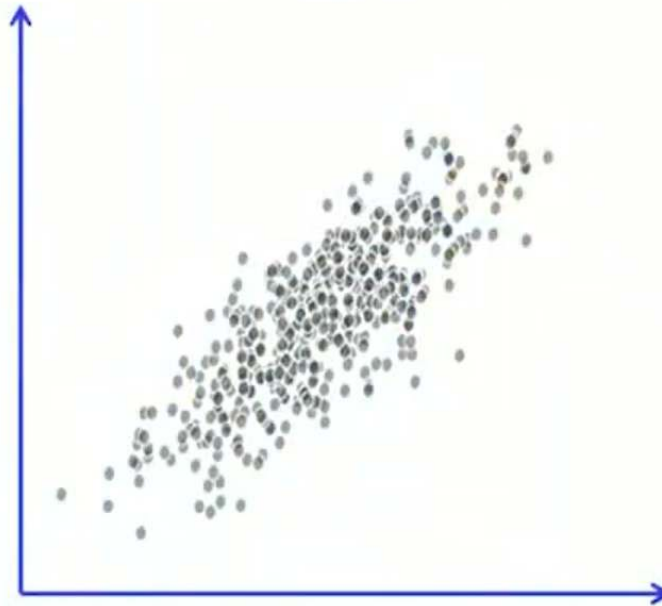
as Causal Detective

Robert Spekkens and Elie Wolfe

Perimeter Institute

Oct. 7, 2020

Amount of
damage done
by fire



Number of
firefighters on scene



Number of
firefighters on
scene



Amount of damage
done by fire





Number of
firefighters on
scene



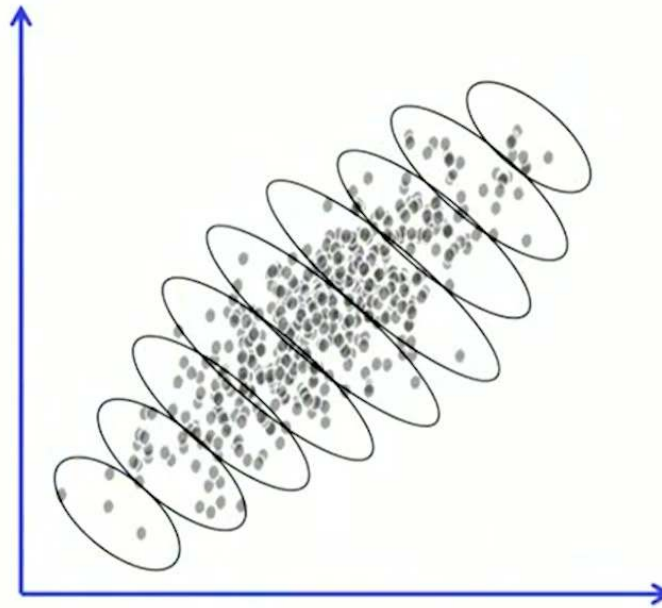
Amount of damage
done by fire



Size of fire

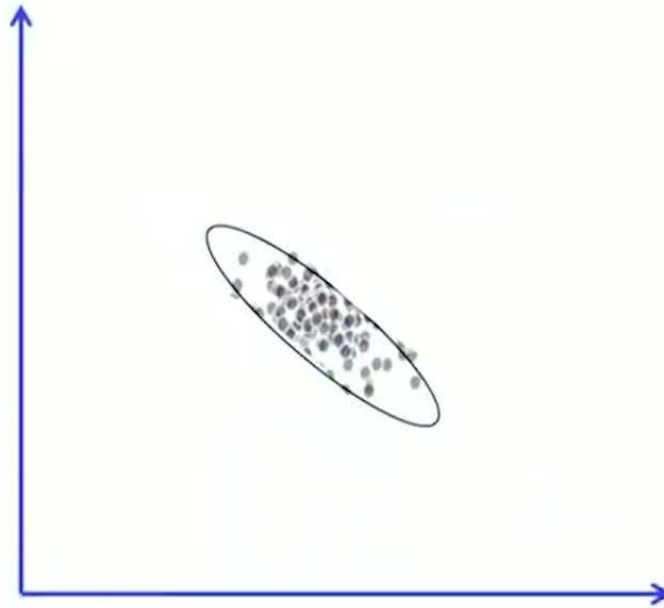


Amount of
damage done
by fire



Number of
firefighters on scene

Amount of
damage done
by fire



Number of
firefighters on scene

THE CLUE

*in the
Medicine Jar*

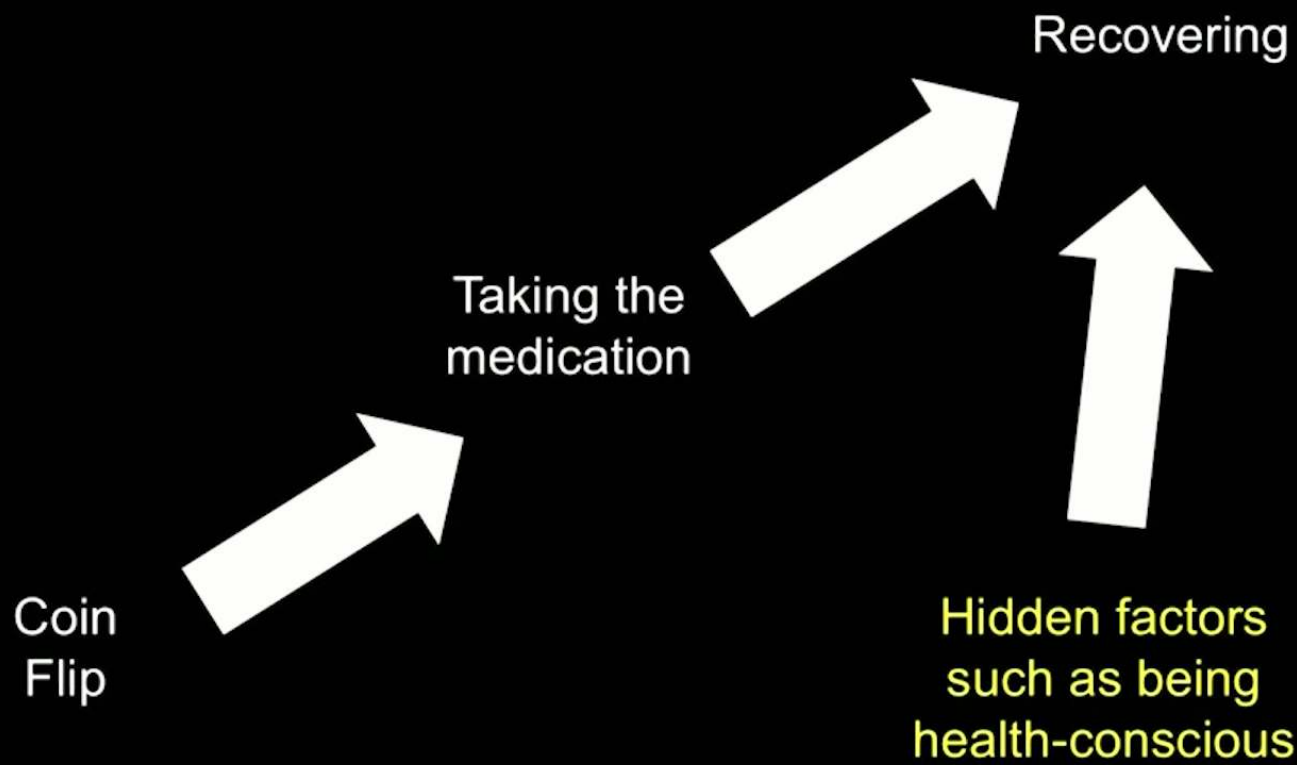


Recovering

Taking the medication

	Yes	No
Yes	79%	21%
No	43%	57%





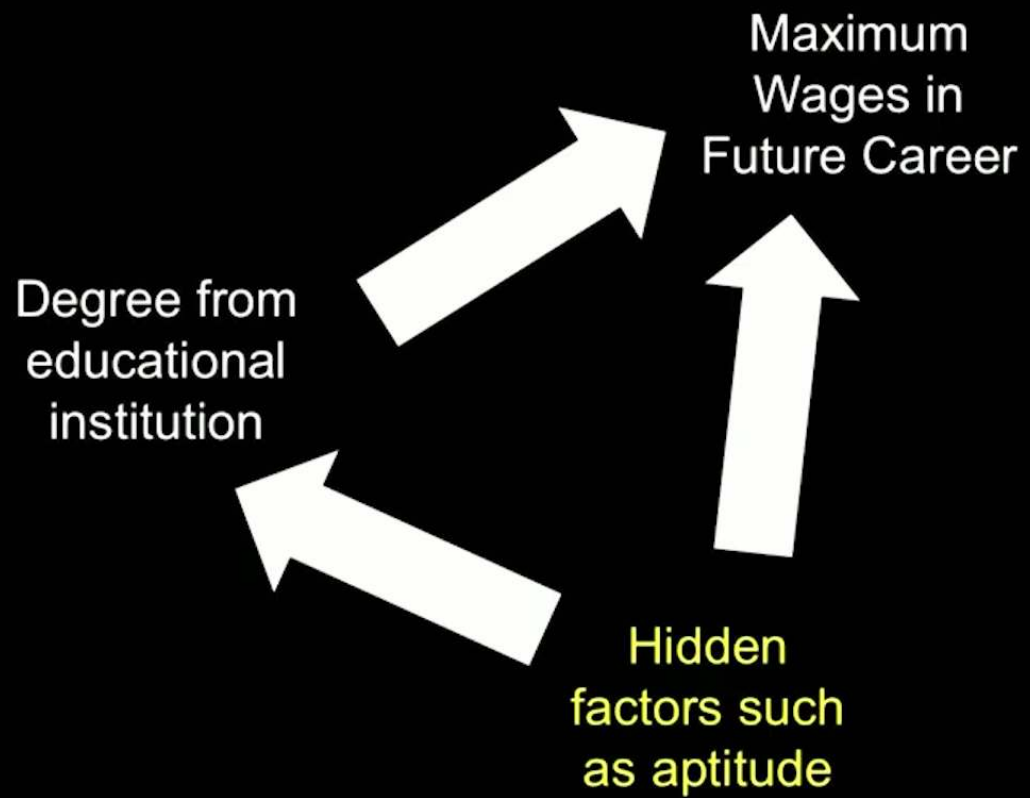
Public Health
Recommends
the Treatment

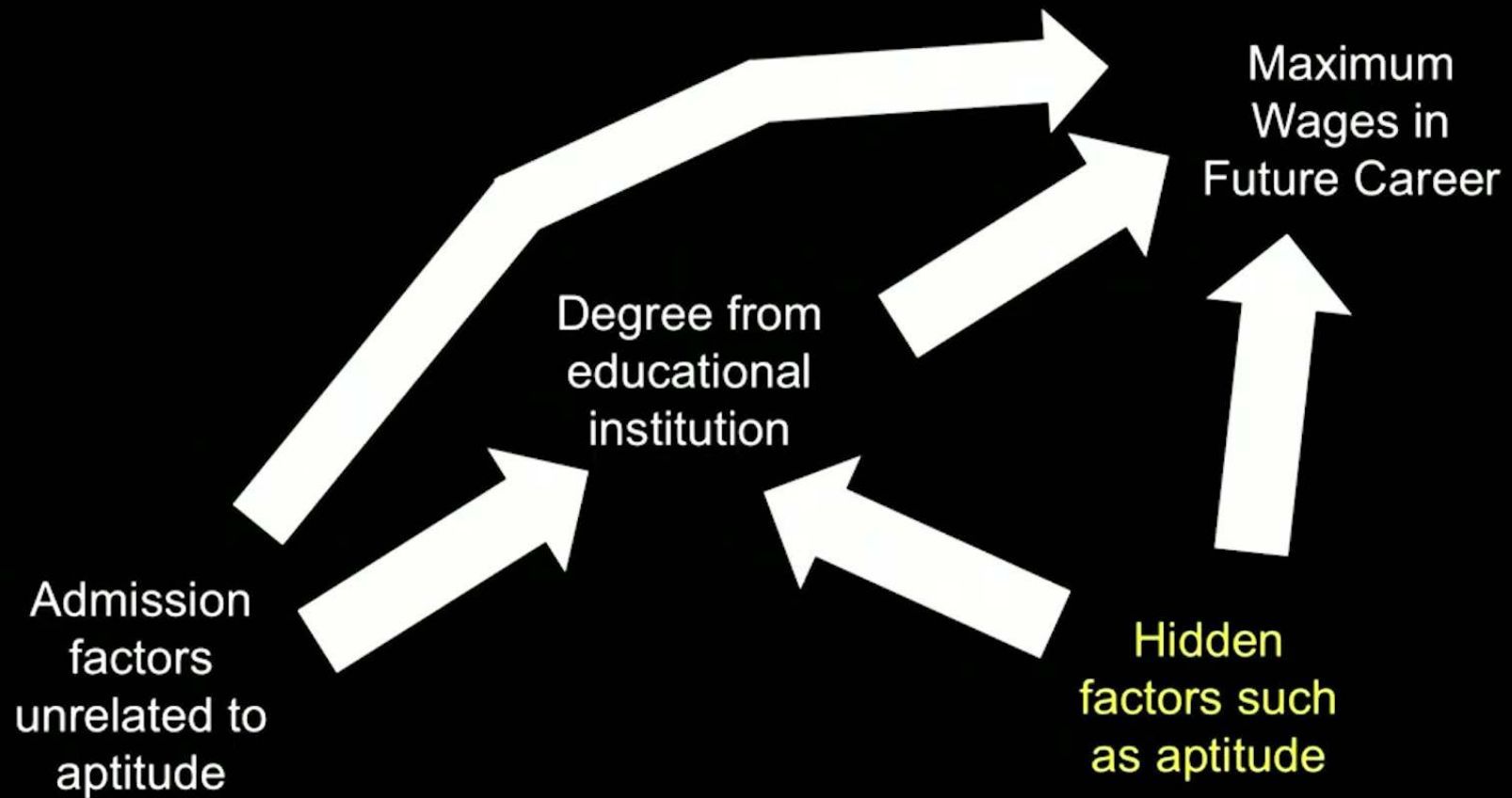
Taking the
medication

Recovering

Hidden factors
such as being
health-conscious

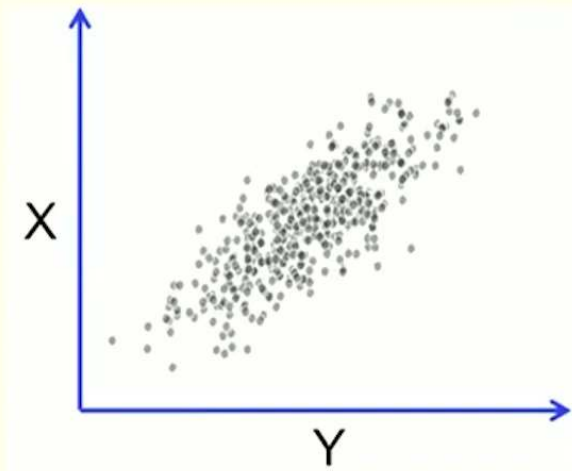




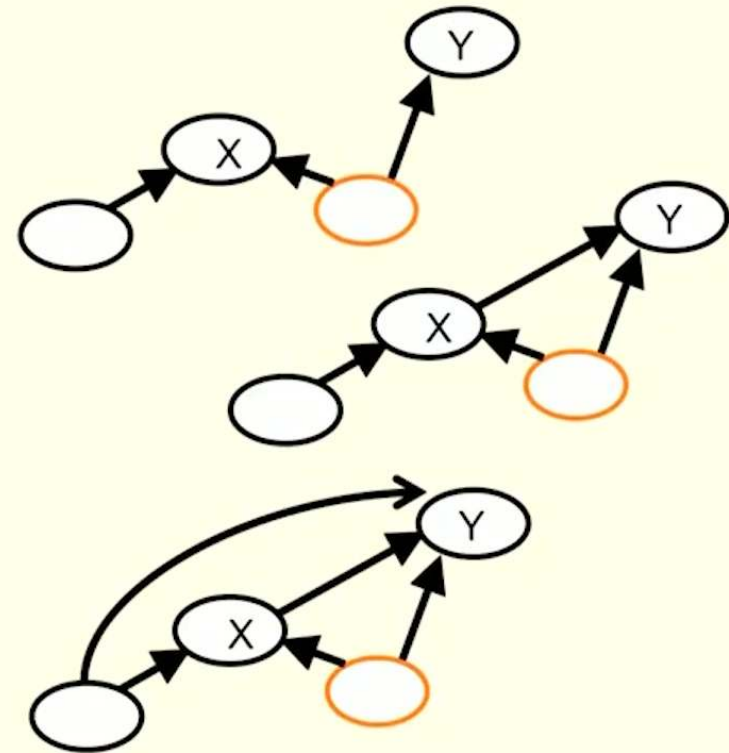


The evidence

	Y=0	Y=1
X=0	0.797	0.203
X=1	0.390	0.610

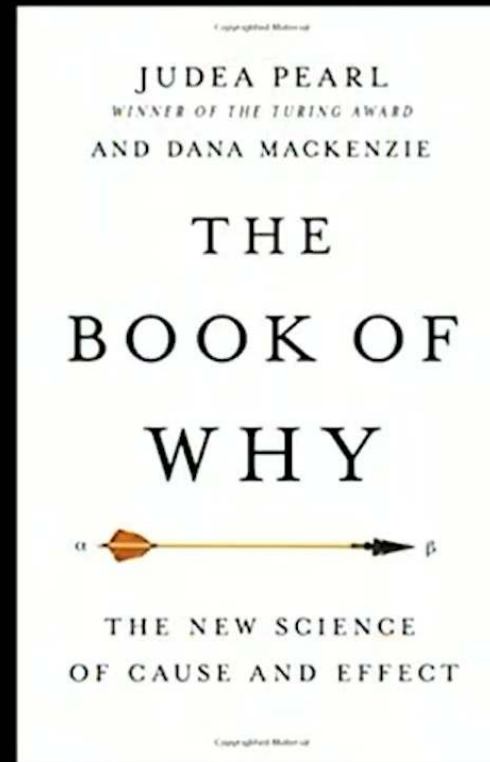


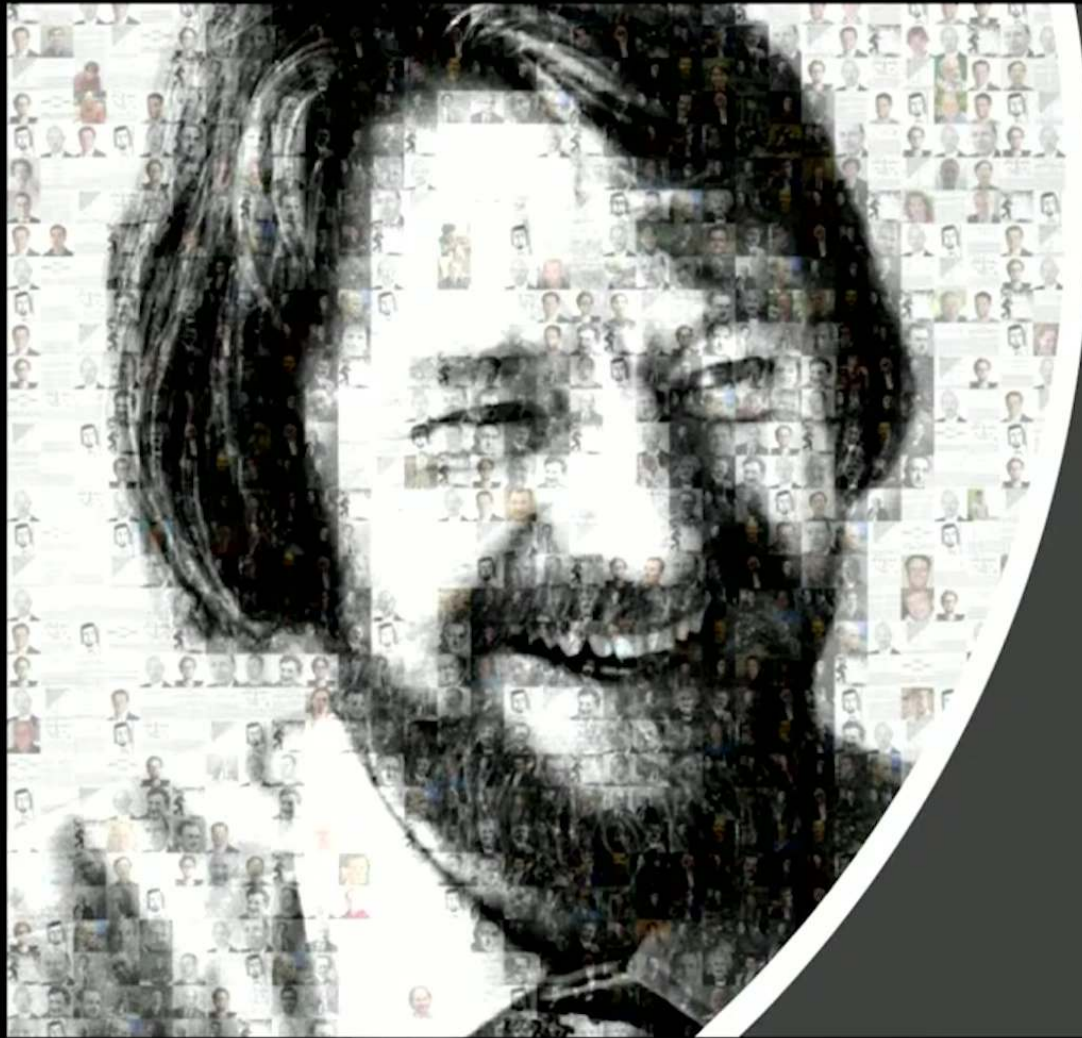
The suspects





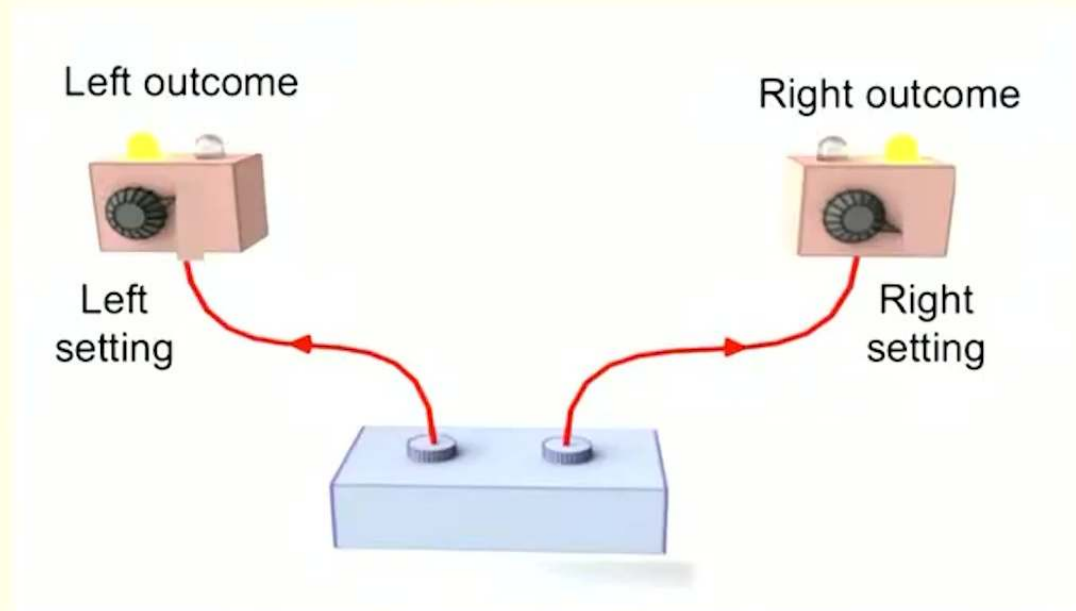
Judea Pearl





John Stuart Bell



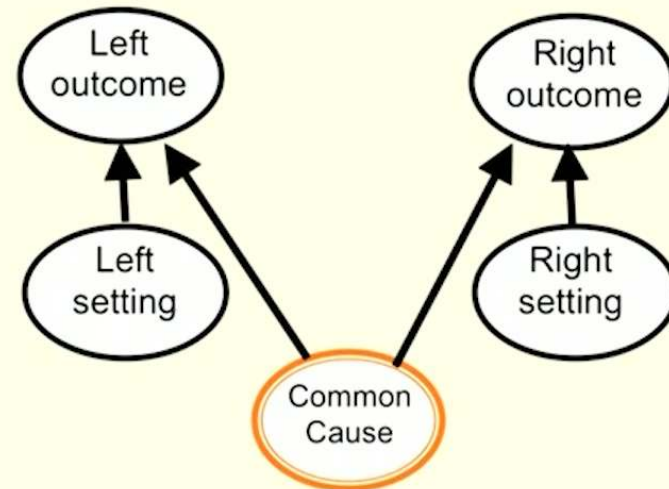


		Left outcome and Right outcome			
		0 and 0	0 and 1	1 and 0	1 and 1
Left setting and Right setting	0 and 0	43%	7%	7%	43%
	0 and 1	43%	7%	7%	43%
	1 and 0	43%	7%	7%	43%
	1 and 1	7%	43%	43%	7%

The evidence

		Left outcome and Right outcome			
		0 and 0	0 and 1	1 and 0	1 and 1
Left setting and Right setting	0 and 0	43%	7%	7%	43%
	0 and 1	43%	7%	7%	43%
	1 and 0	43%	7%	7%	43%
	1 and 1	7%	43%	43%	7%

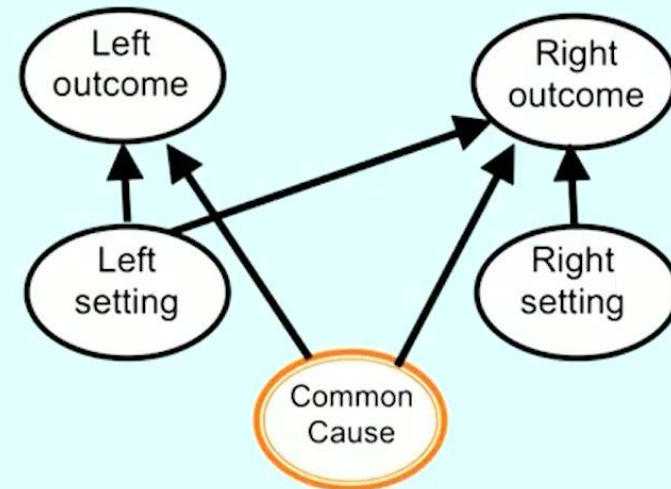
The 1st suspect



The evidence

		Left outcome and Right outcome			
		0 and 0	0 and 1	1 and 0	1 and 1
Left setting and Right setting	0 and 0	43%	7%	7%	43%
	0 and 1	43%	7%	7%	43%
	1 and 0	43%	7%	7%	43%
	1 and 1	7%	43%	43%	7%

The 2nd suspect

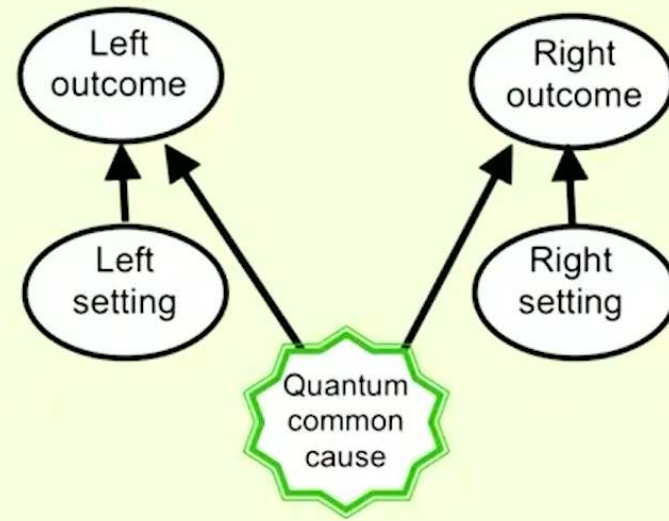


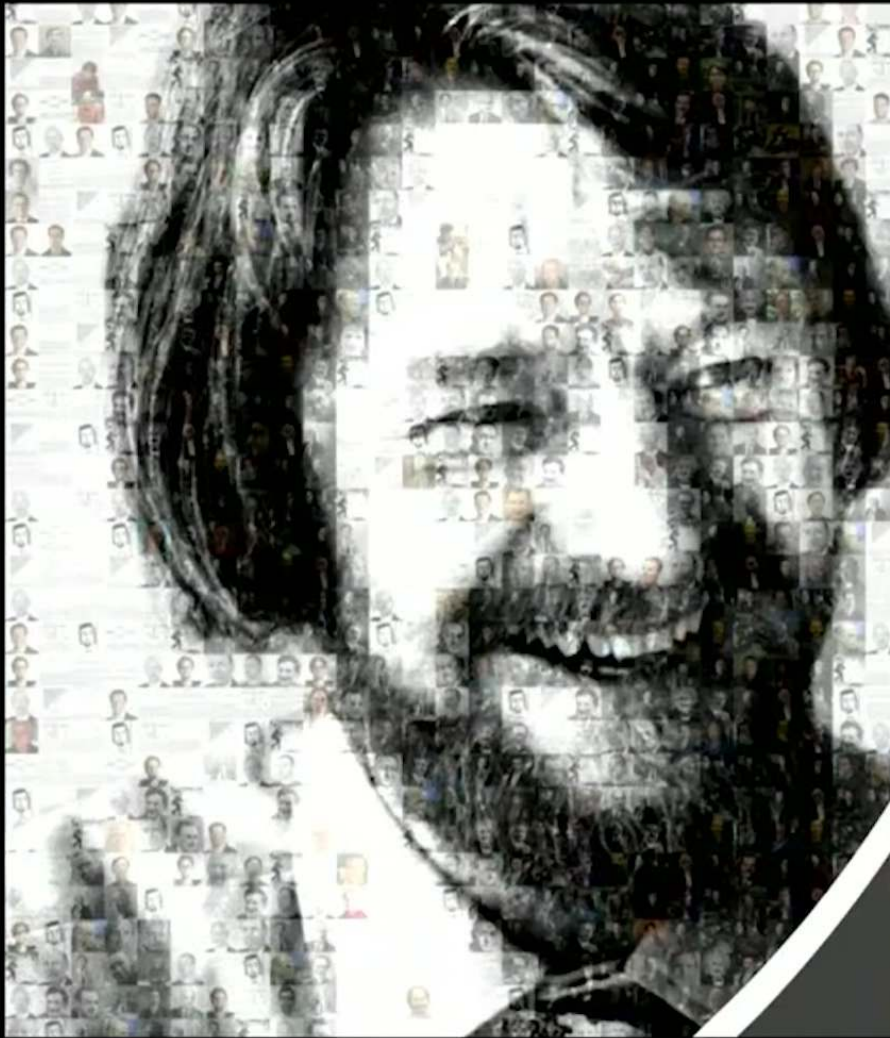
Compatible

The evidence

		Left outcome and Right outcome			
		0 and 0	0 and 1	1 and 0	1 and 1
Left setting and Right setting	0 and 0	43%	7%	7%	43%
	0 and 1	43%	7%	7%	43%
	1 and 0	43%	7%	7%	43%
	1 and 1	7%	43%	43%	7%

The 3rd suspect

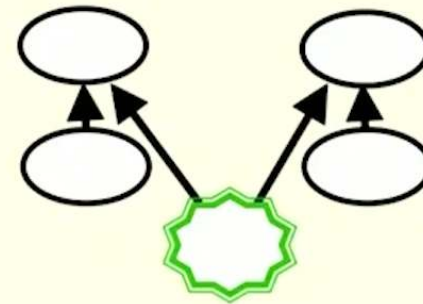




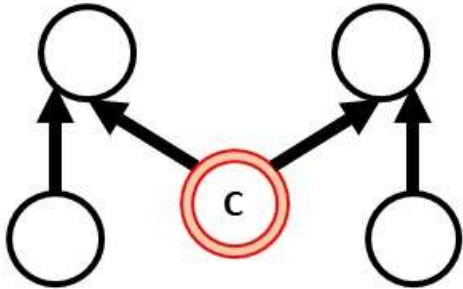
Violation of Bell inequalities



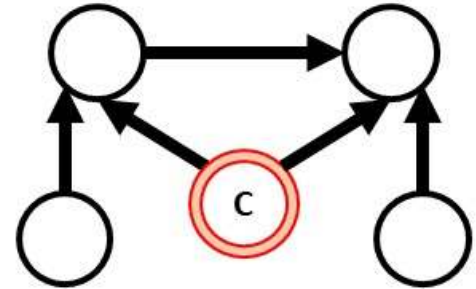
Witnessing quantumness



“Eliminate the Impossible”



vs.



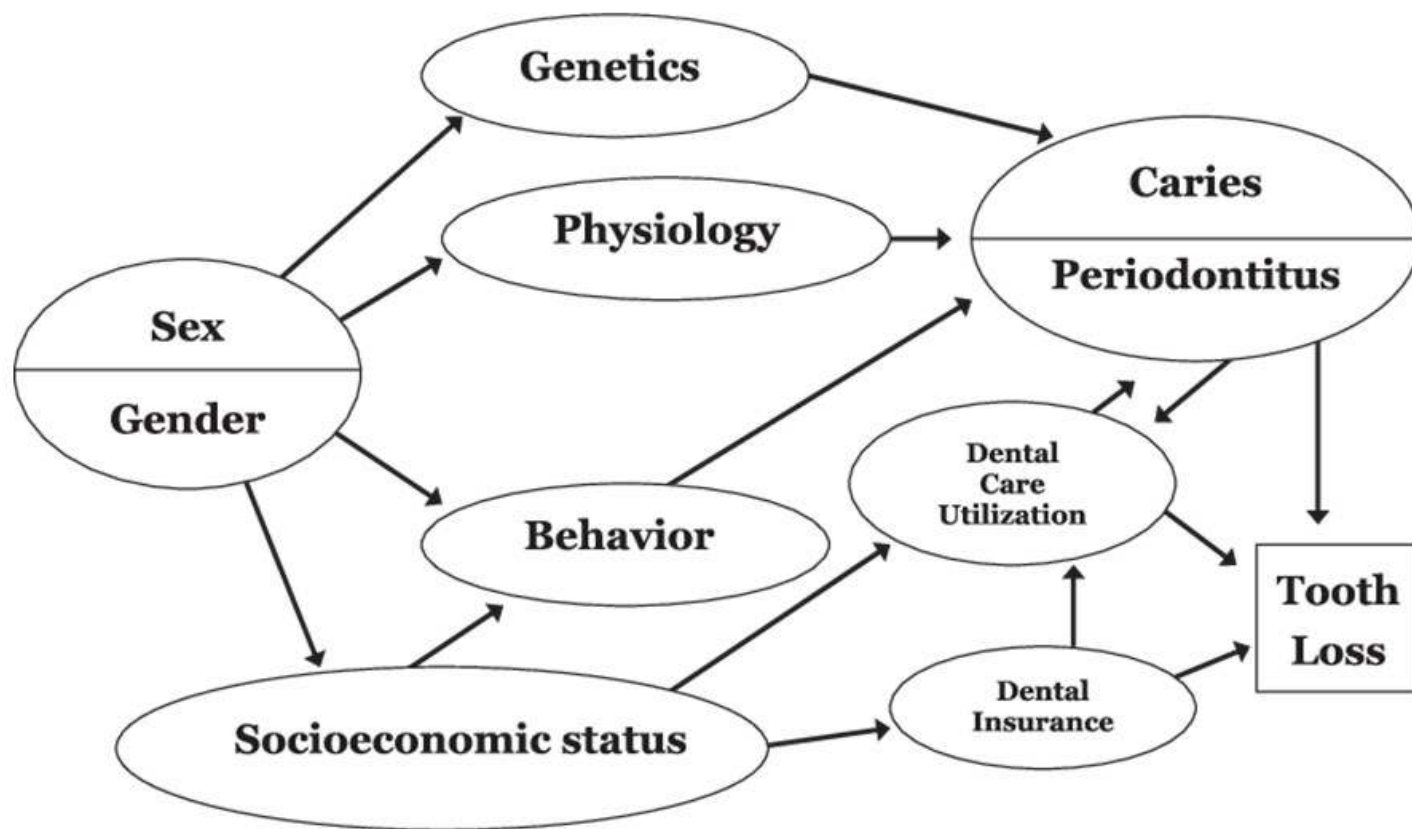
Causa



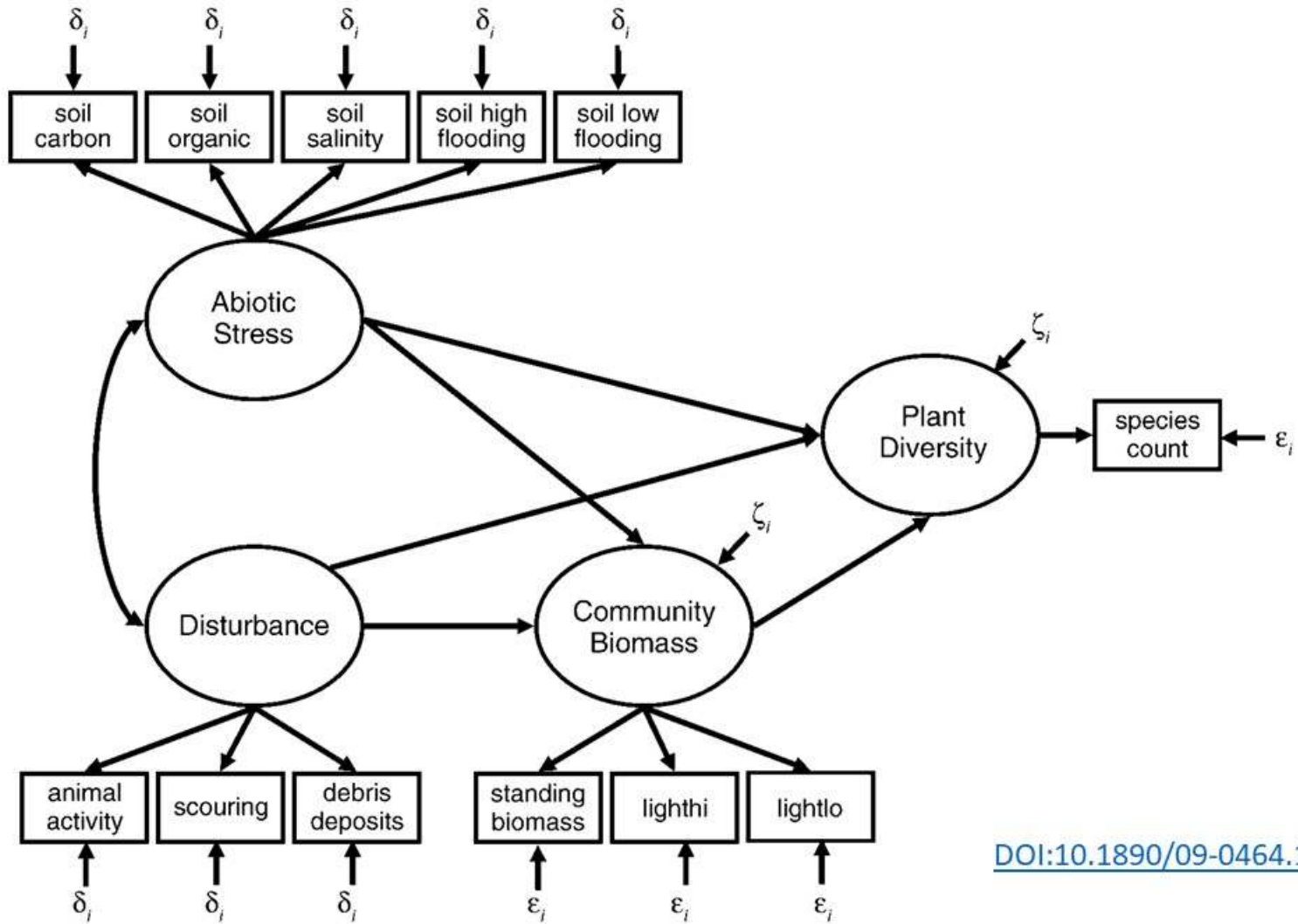
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Causal
Structures
come in
Great Variety

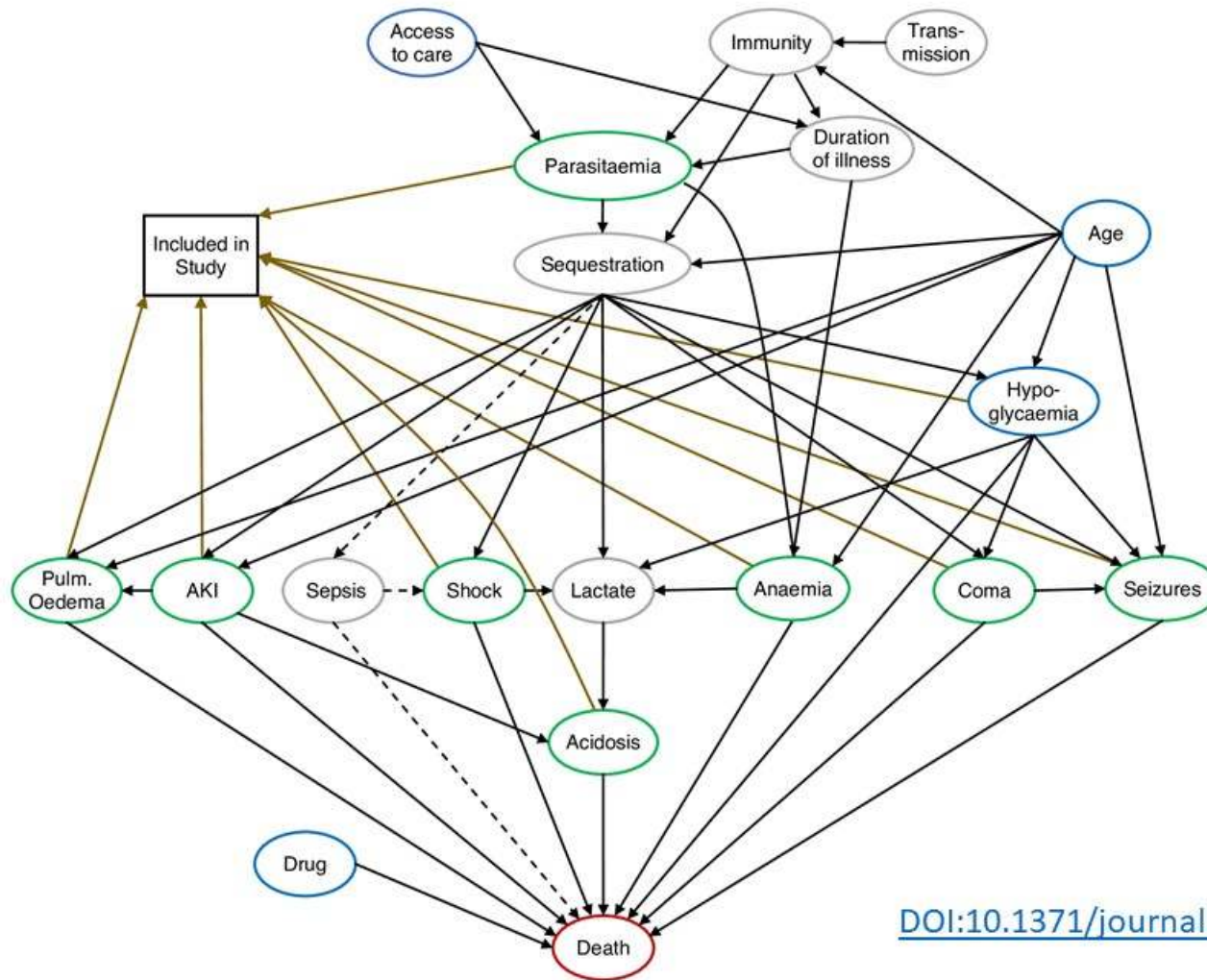




[DOI:10.1016/j.cden.2013.02.006](https://doi.org/10.1016/j.cden.2013.02.006)



[DOI:10.1890/09-0464.1](https://doi.org/10.1890/09-0464.1)



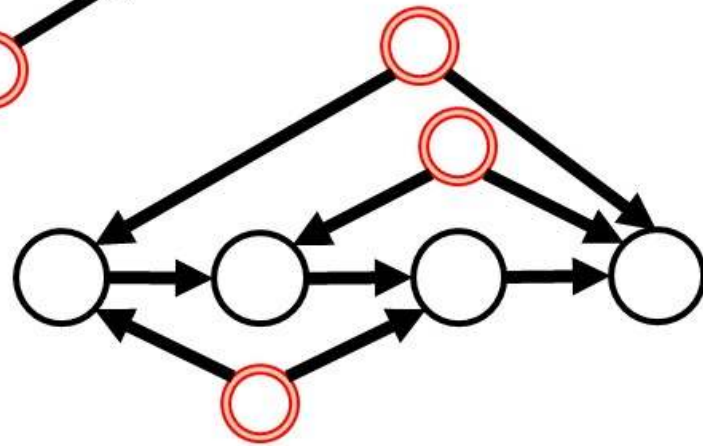
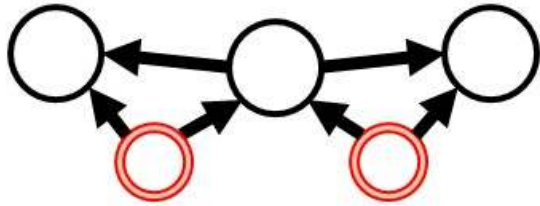
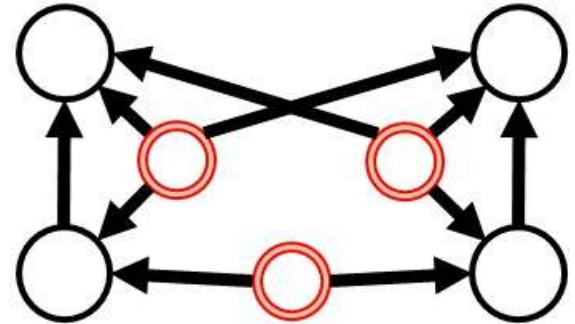
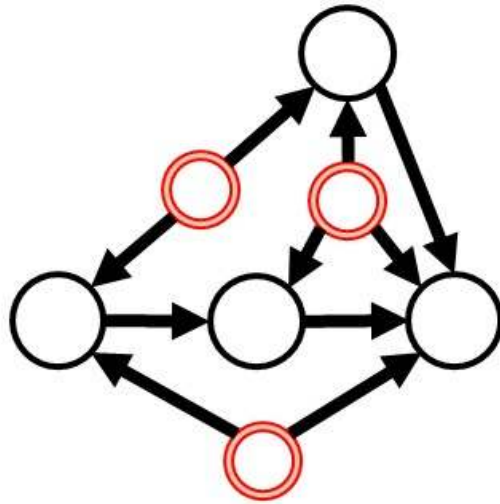
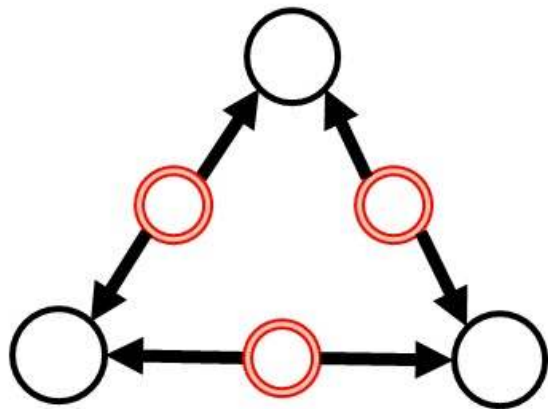
[DOI:10.1371/journal.pmed.1002858](https://doi.org/10.1371/journal.pmed.1002858)

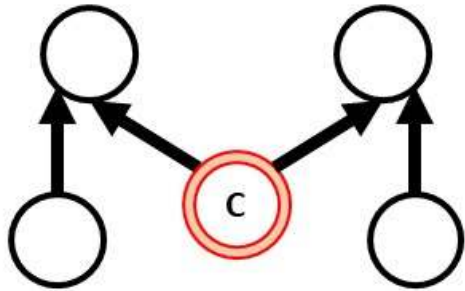


50 years of
experience

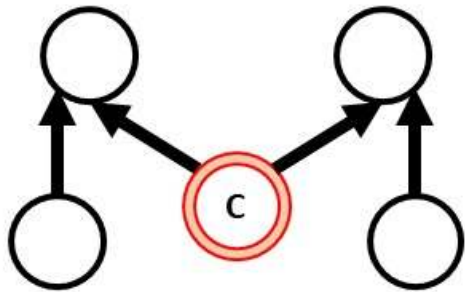
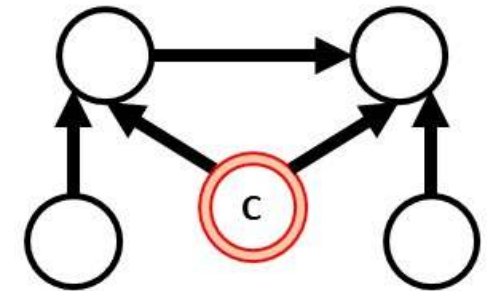
“The Inflation Technique for Causal Inference”



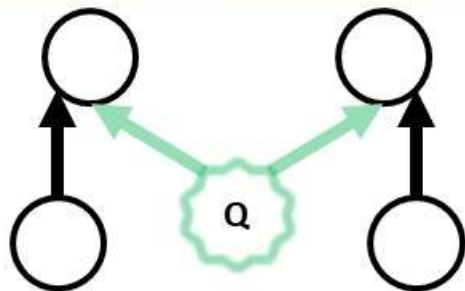
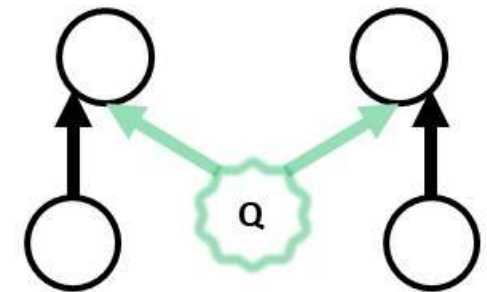




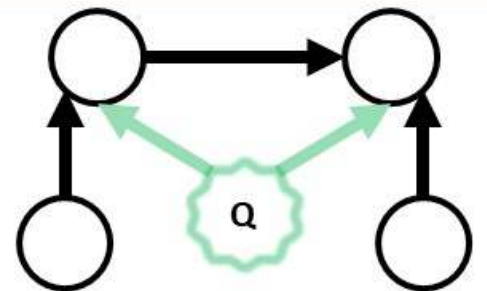
Classical vs. Classical



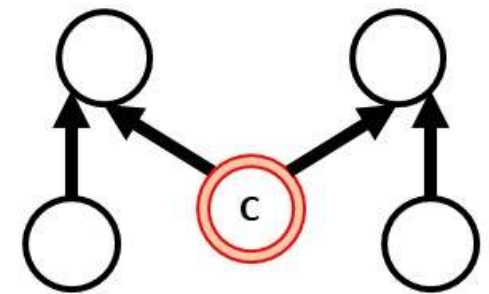
Classical vs. Quantum



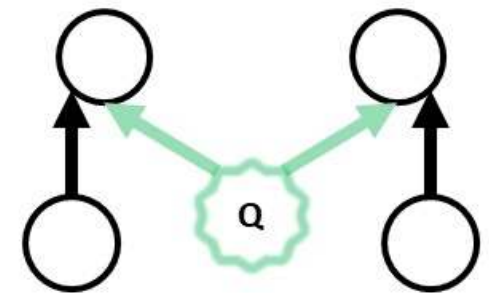
Quantum vs. Quantum



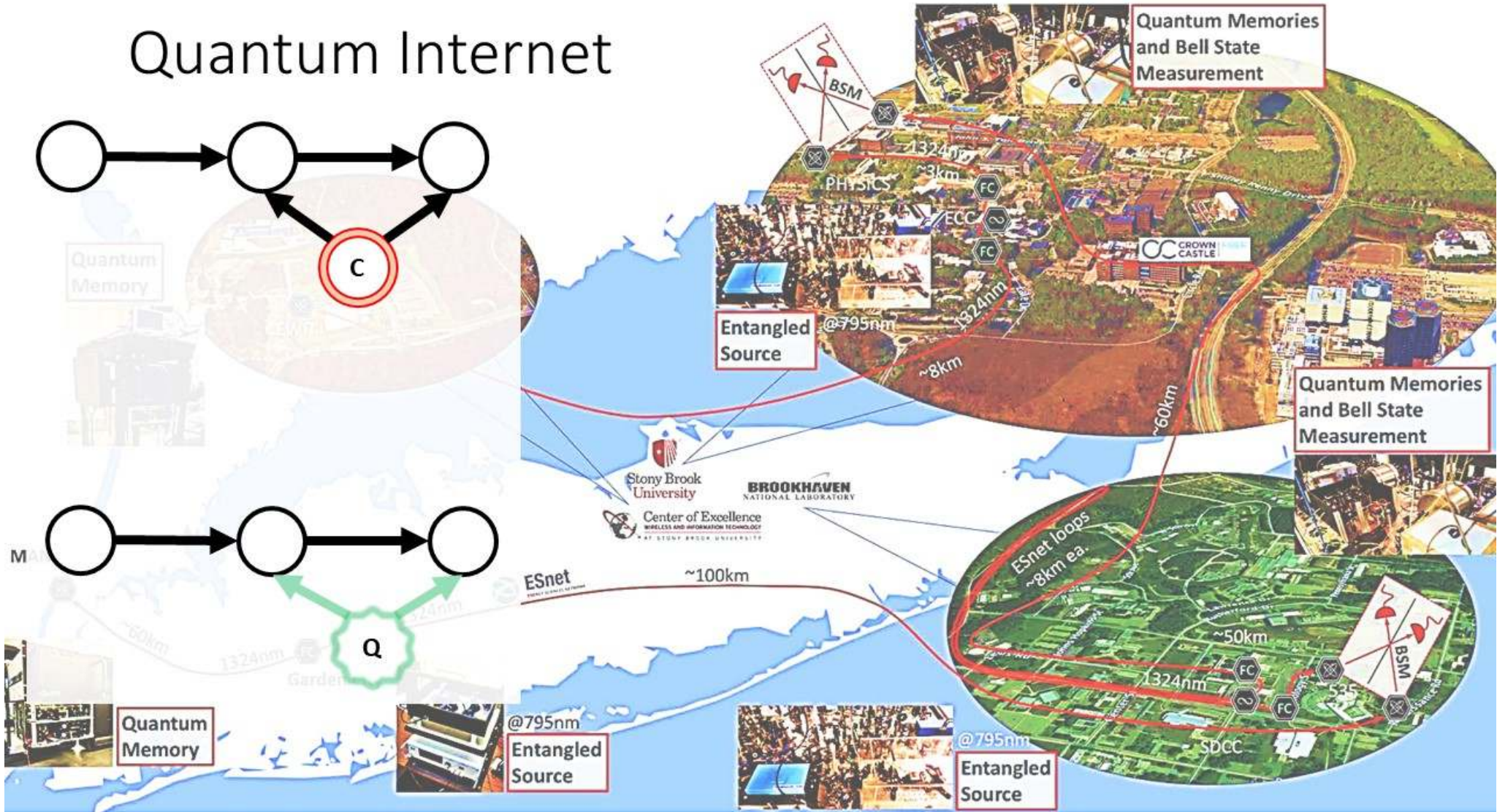
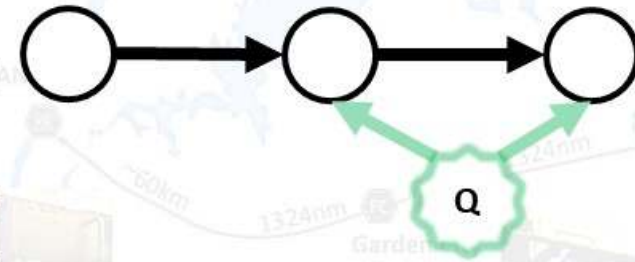
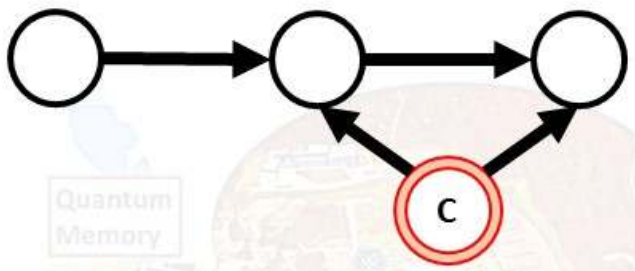
Quantum Cryptography

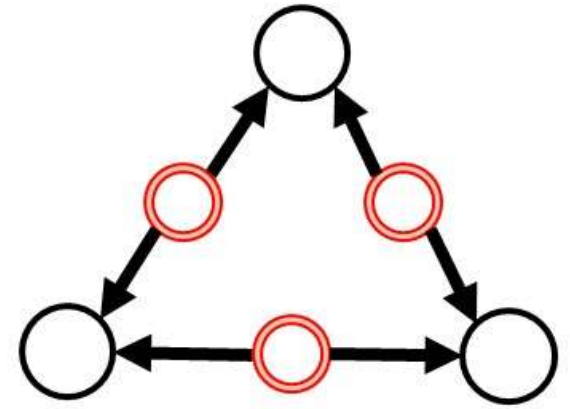


VS.

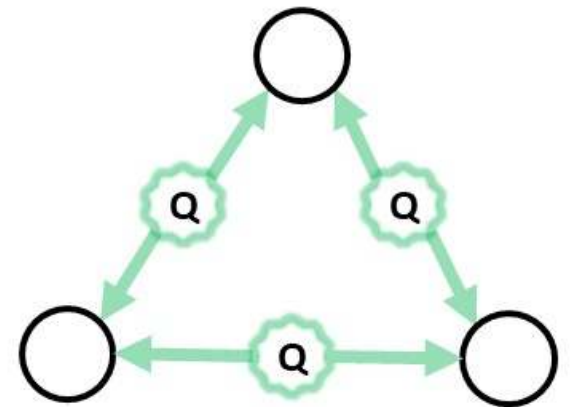


Quantum Internet

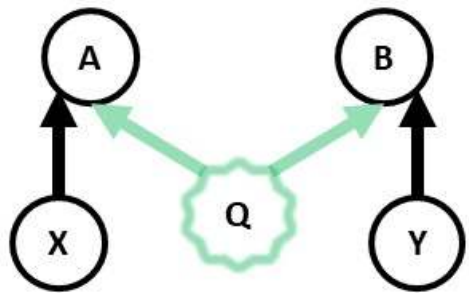




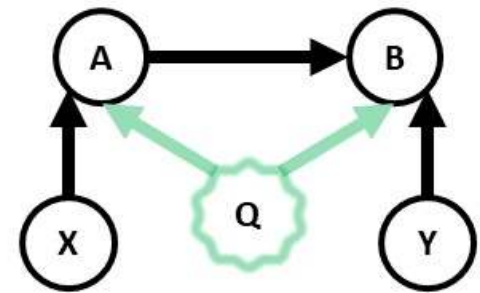
vs.



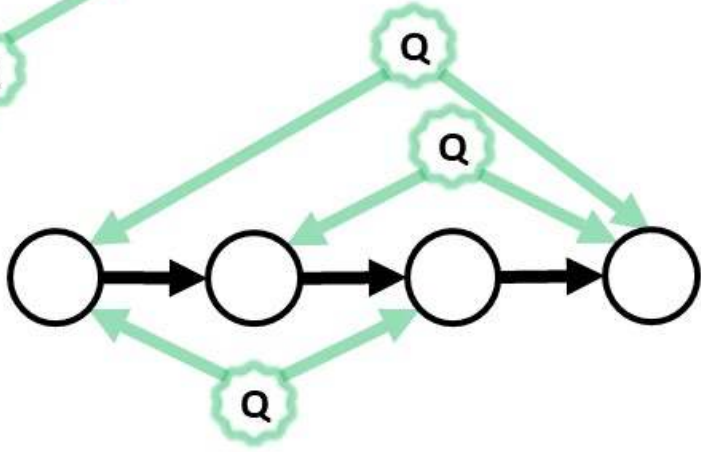
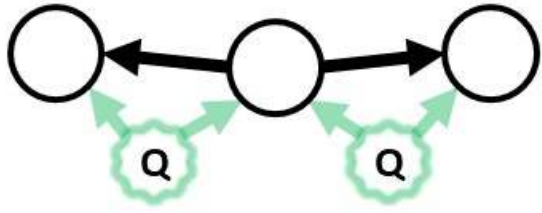
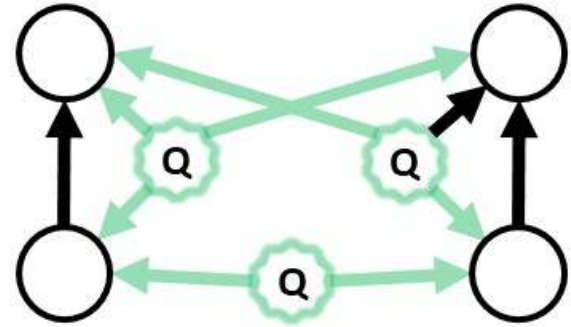
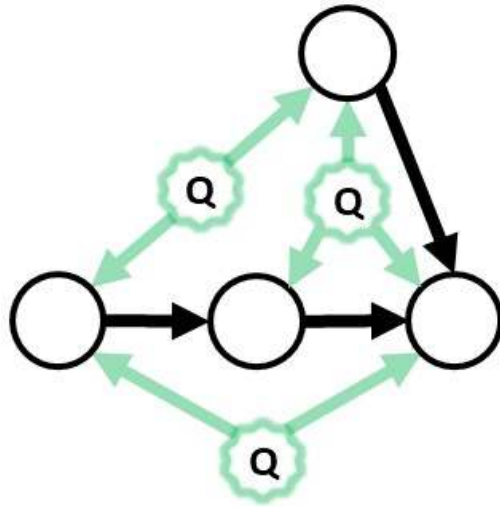
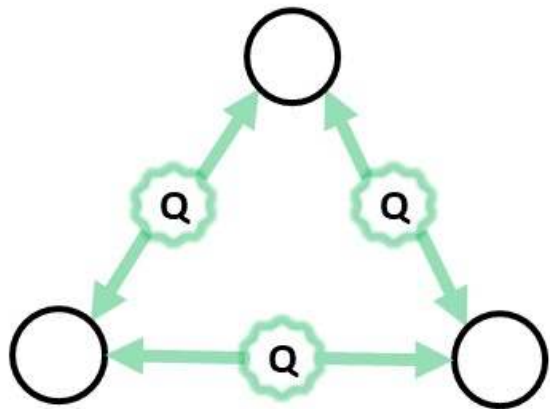
Quantum vs. Quantum



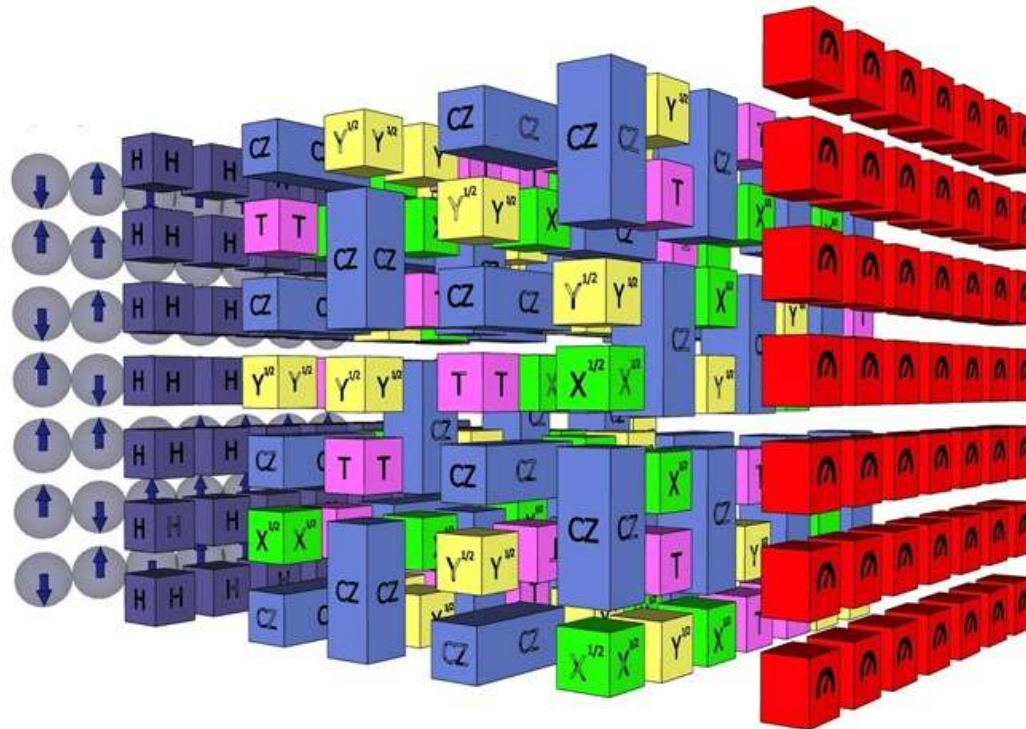
vs.



Causal inference in the presence of **quantum common causes**

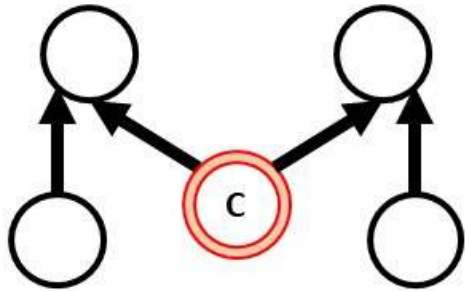


Hardware Diagnostics



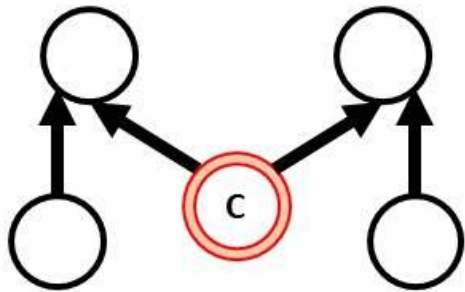
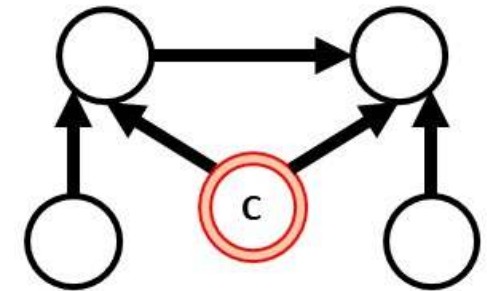
ai.googleblog.com/2018/05/the-question-of-quantum-supremacy.html





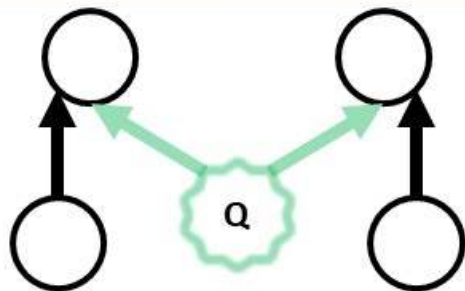
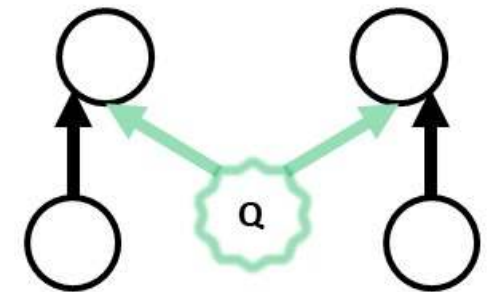
Classical vs. Classical

Physicists have experience



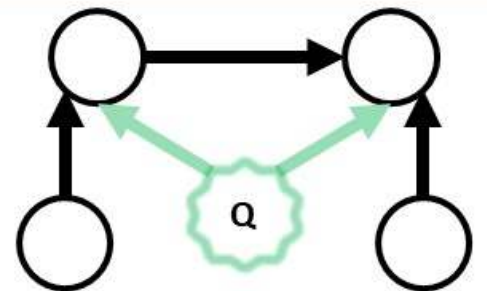
Classical vs. Quantum

Recognizing quantum advantages



Quantum vs. Quantum

Diagnosing quantum processes



THE CLUE *in the* *Medicine Jar*

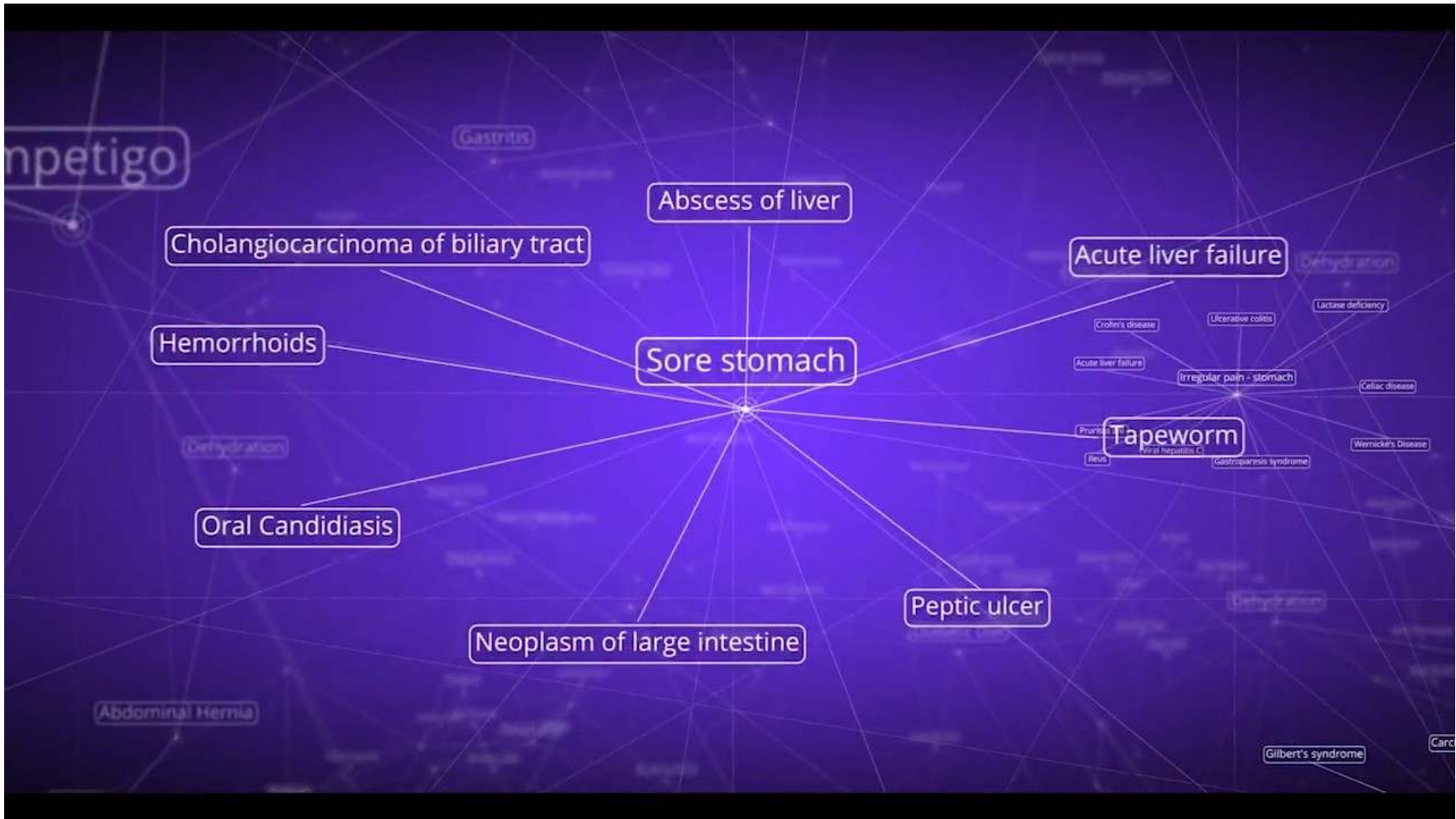


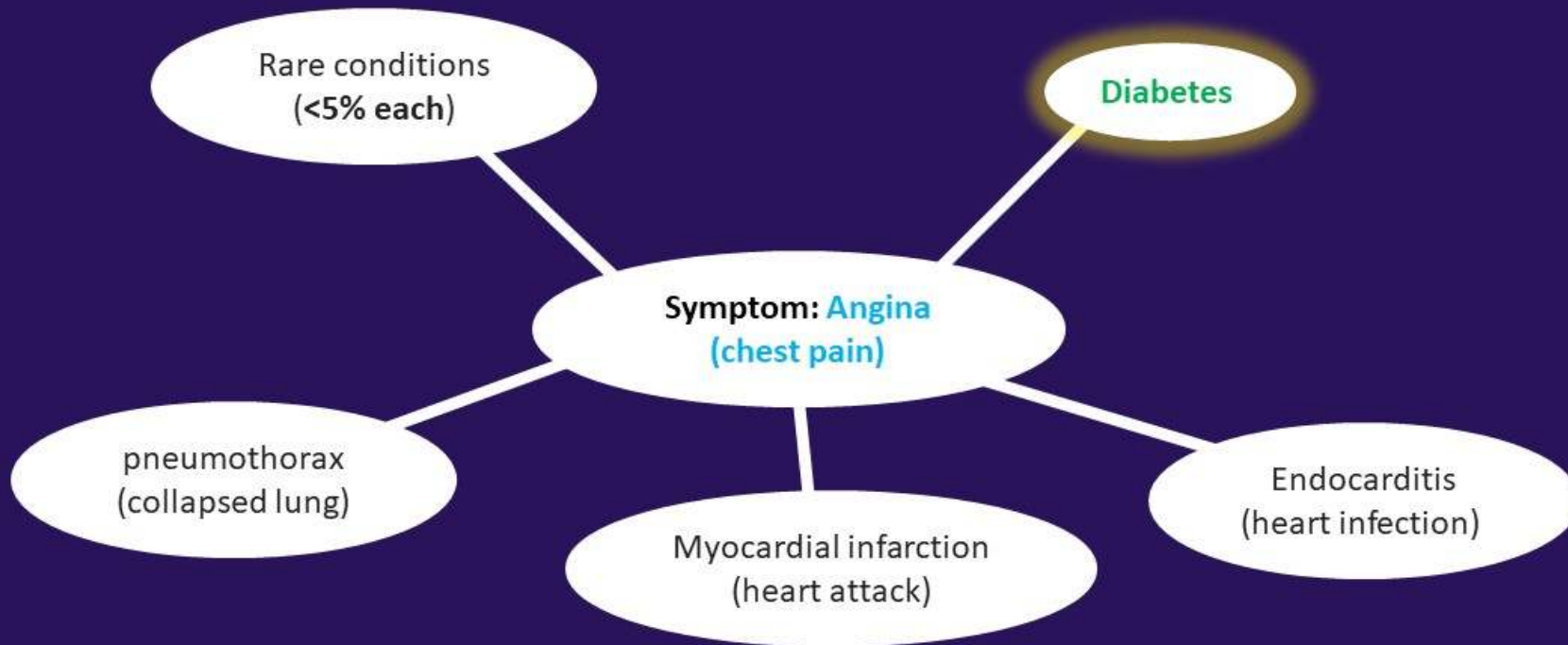
Ciarán M. Gilligan-Lee

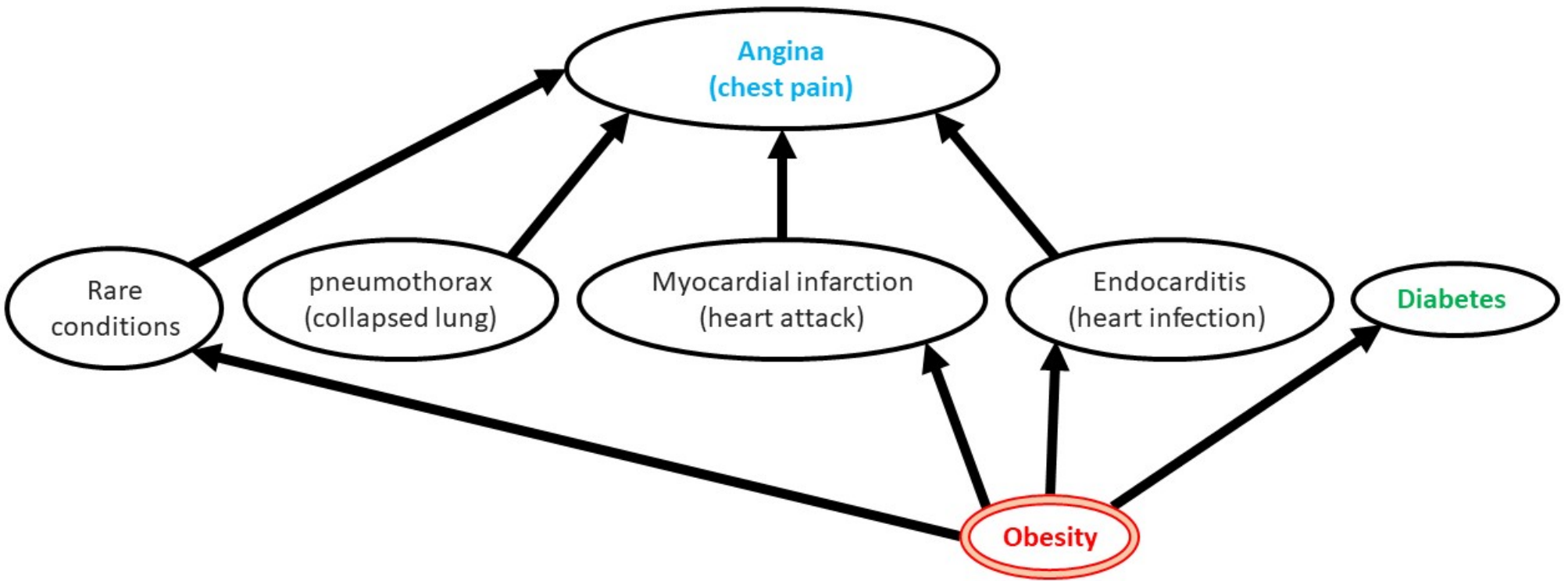
&

Babylon Health









“Draw your assumptions before your conclusions.”

--- Miguel Hernán

Professor of Biostatistics and Epidemiology
Harvard University

